Managing Forests for Sustainable Harvest and Wildlife Habitat Using Earth Observations and Modeling of Forest Structure and Landscape Connectivity

Andrew J Elmore, Matt C Fitzpatrick
U of Maryland Center for Environmental Science
Appalachian Laboratory, Frostburg, MD

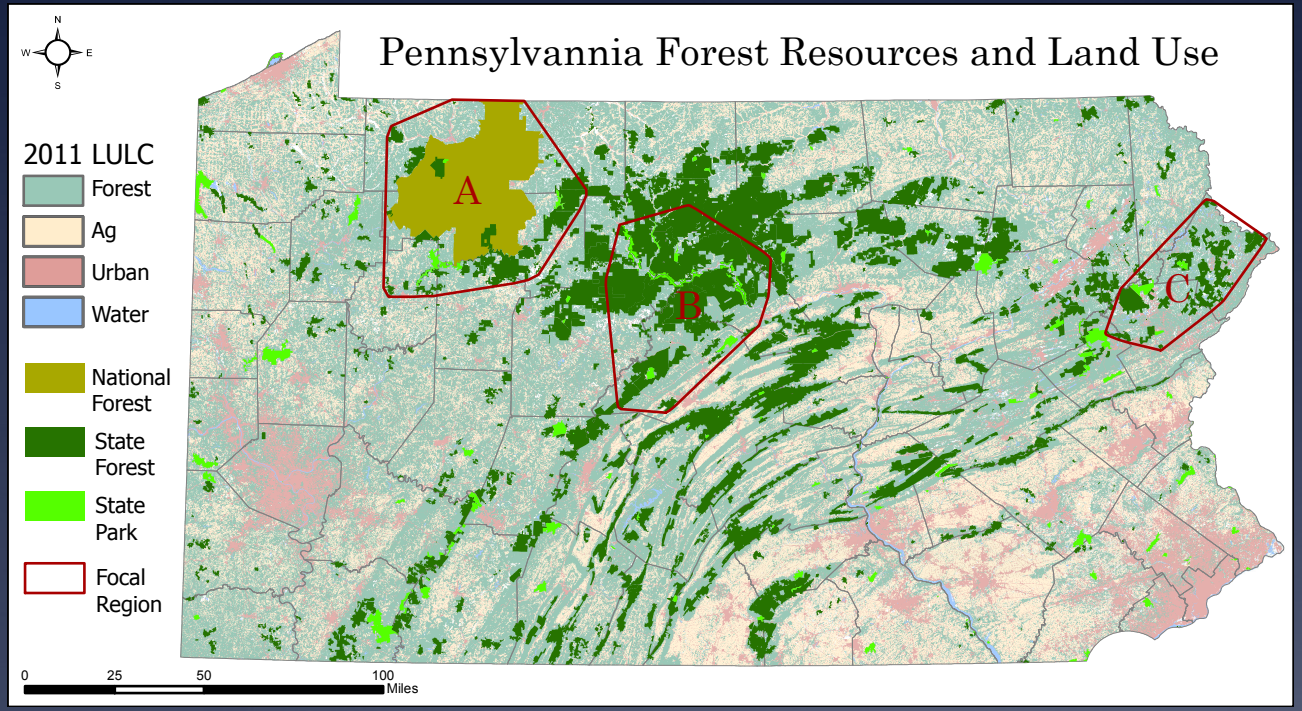
Jeff Larkin
Indiana University of Pennsylvania and
The American Bird Conservancy

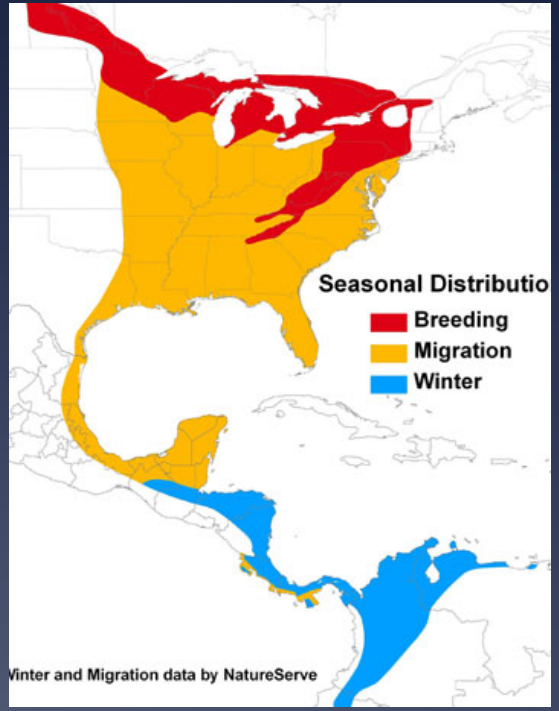
Collin Shepherd
USFS Allegany National Forest

Joseph Petroski
PA Department of Conservation
and Natural Resources

Ben Jones
PA Game Commission

Management of PA forests for bird habitat

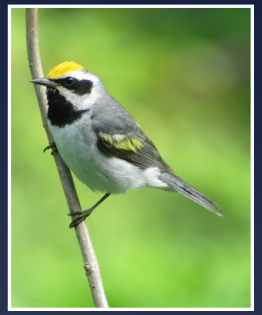


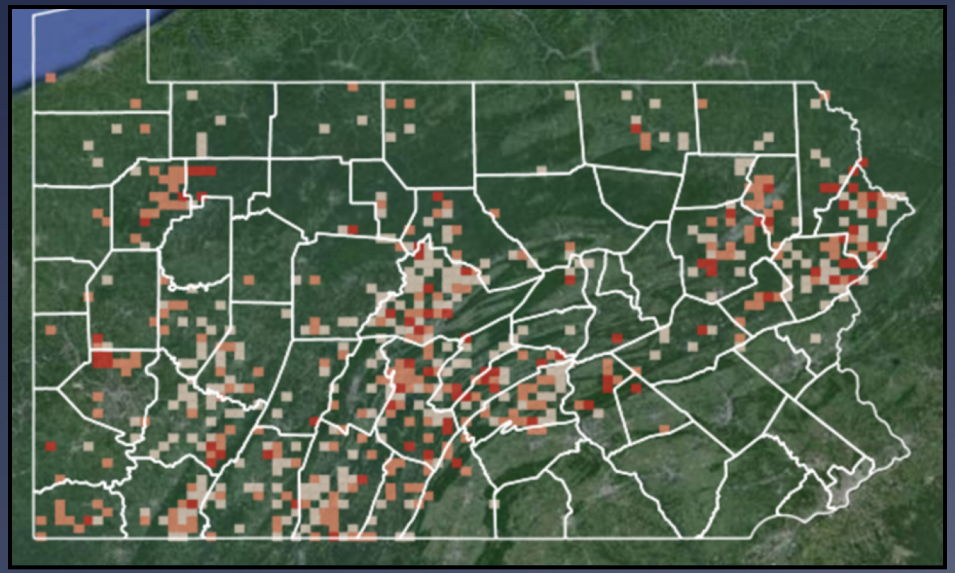


- 40% of the 16.7 million acres of forest in PA are greater than 80 years old
- >50% of PA forests are fully stocked with a net growth-to-removal ratio of 2:1
- Lack of early successional forest habitat is associated with **declines** in populations of Golden-winged Warbler, Cerulean Warbler, and Wood Thrush.
- **Increases** in population size observed in a variety of other bird species, including the Pileated woodpecker, Yellow-bellied sapsucker, Acadian Flycatcher, Yellow-throated vireo, Ovenbird, Worm-eating warbler, Hooded-warbler, Magnolia warbler, Black-throated blue warbler, and Black-throated green warbler.

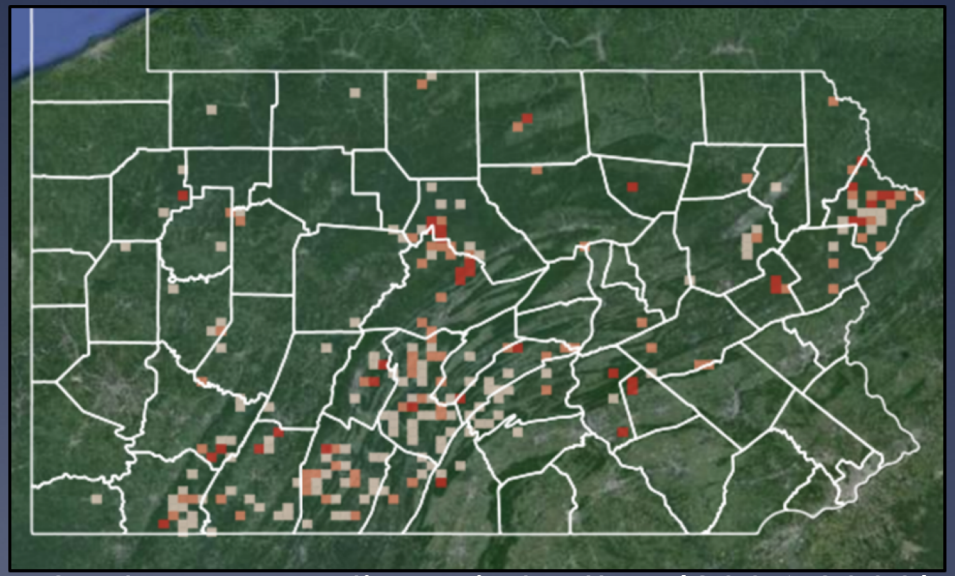
Golden-winged Warblers population decline

- ~2.3% decline per year range wide (North American BBS; Sauer et al. 2017)
- 61% decline in occupancy in 20 yrs (PA Breeding Bird Atlas)



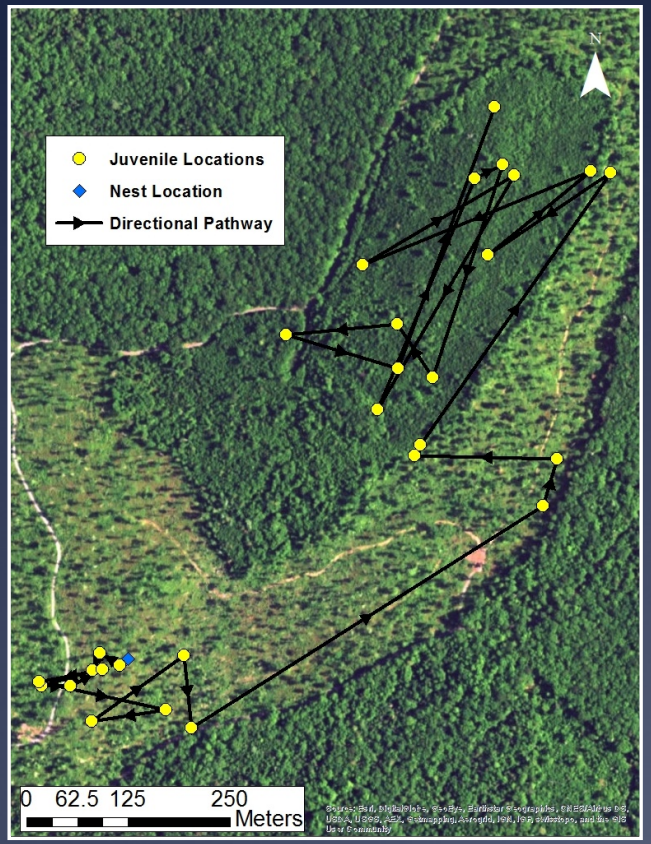


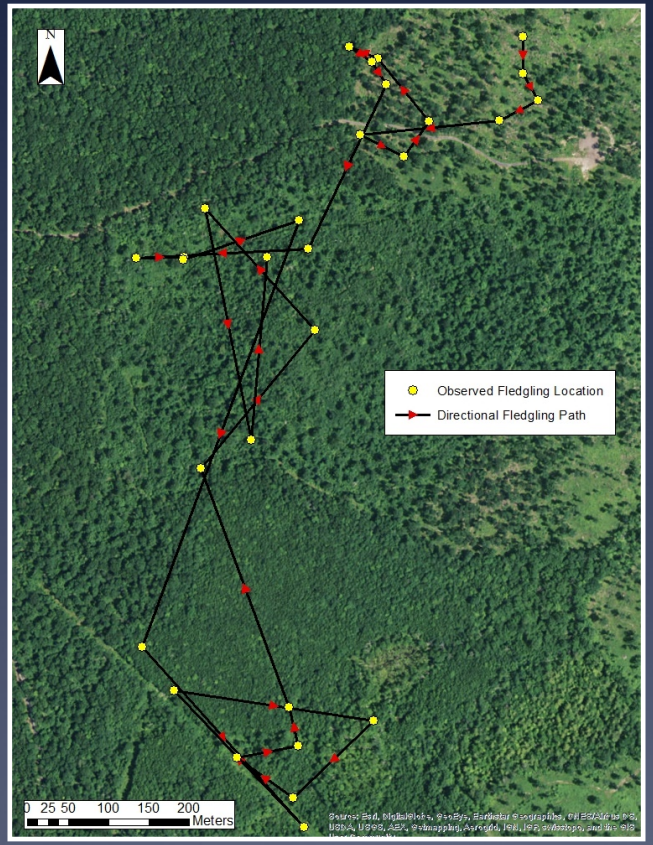
1st PA Breeding Bird Atlas (1984-1988)



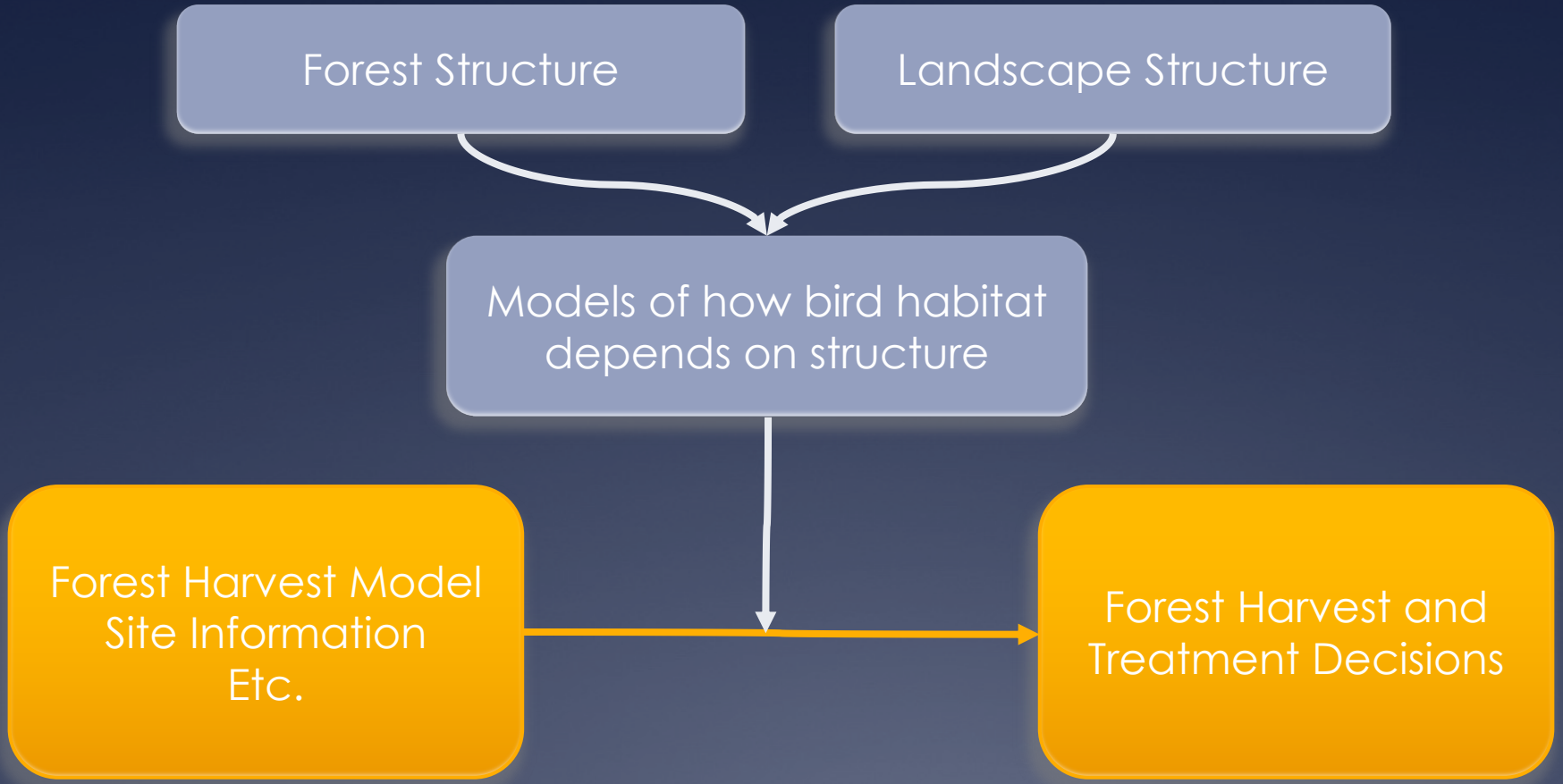
2nd PA Breeding Bird Atlas (2004-2008)

Fledgling movement data demonstrate the importance of landscape structure



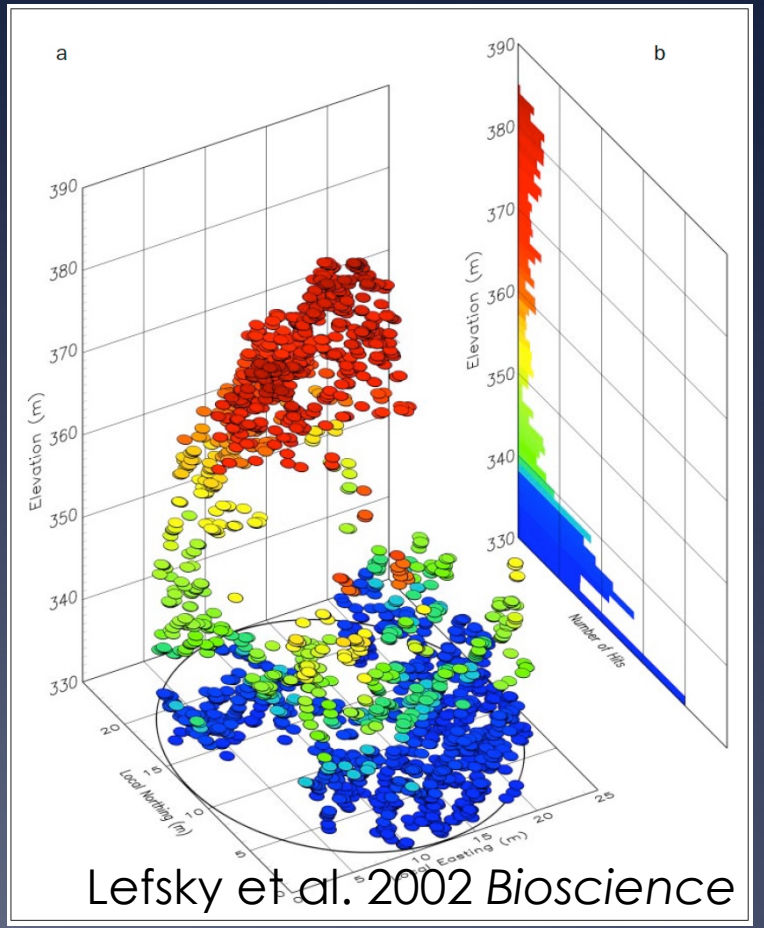


Project Conceptual Framework



Lidar Metrics

1. Mean canopy height (CH)
2. 95% Canopy Height
3. Standard deviation of CH
4. Coefficient of variation of canopy height
5. Percent of first returns > 2m
6. Percent of first returns > mean canopy height
7. Height of the median return (HOME)
8. Vertical distribution ratio (VDR)



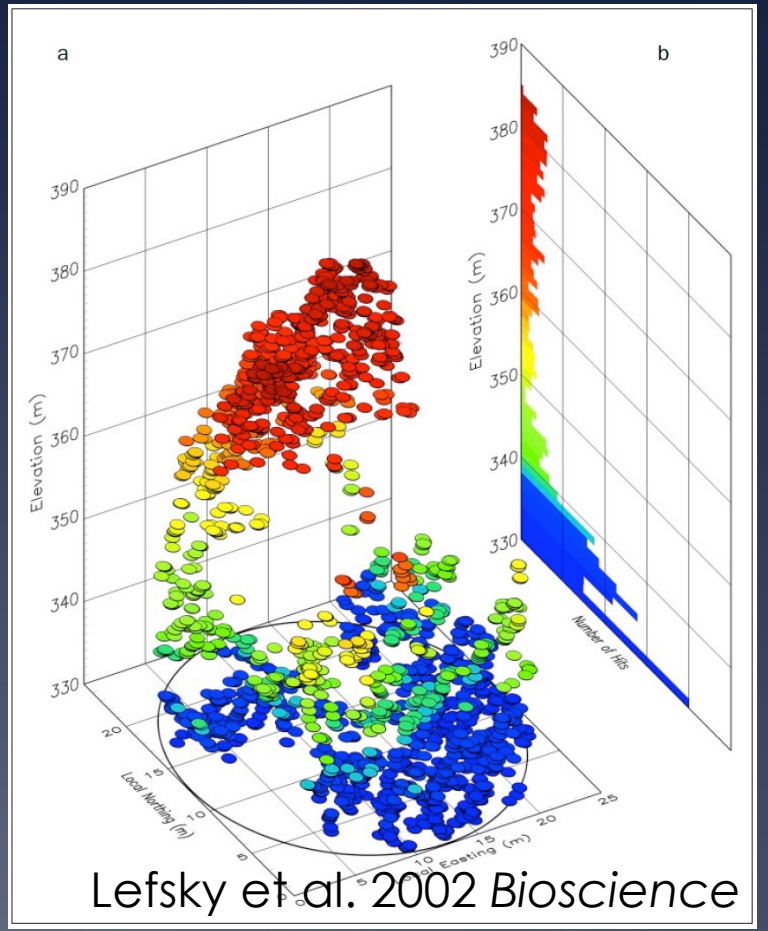
Lefsky et al. 2002 *Bioscience*

Statistical Description

1. Use Principal Components Analysis (PCA) to condense variability in LiDAR point cloud into a few dimensions

2. Use this reduced dimensionality to quantify forest structure, classify patches, and as covariates of bird habitat suitability

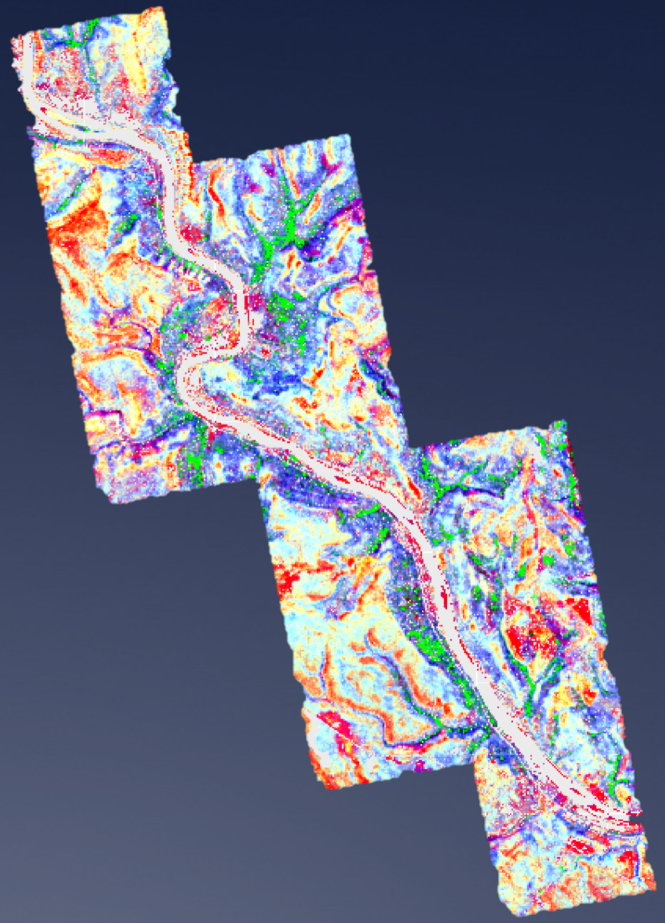
3. Based on proportions of returns in each voxel – and intensity & greenness



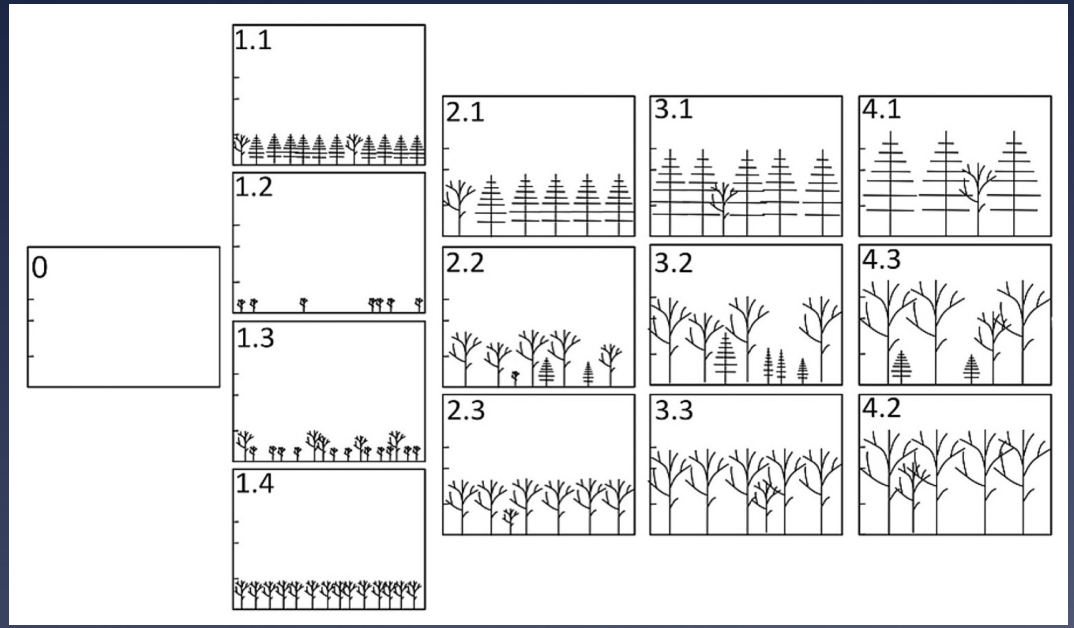
Lefsky et al. 2002 *Bioscience*

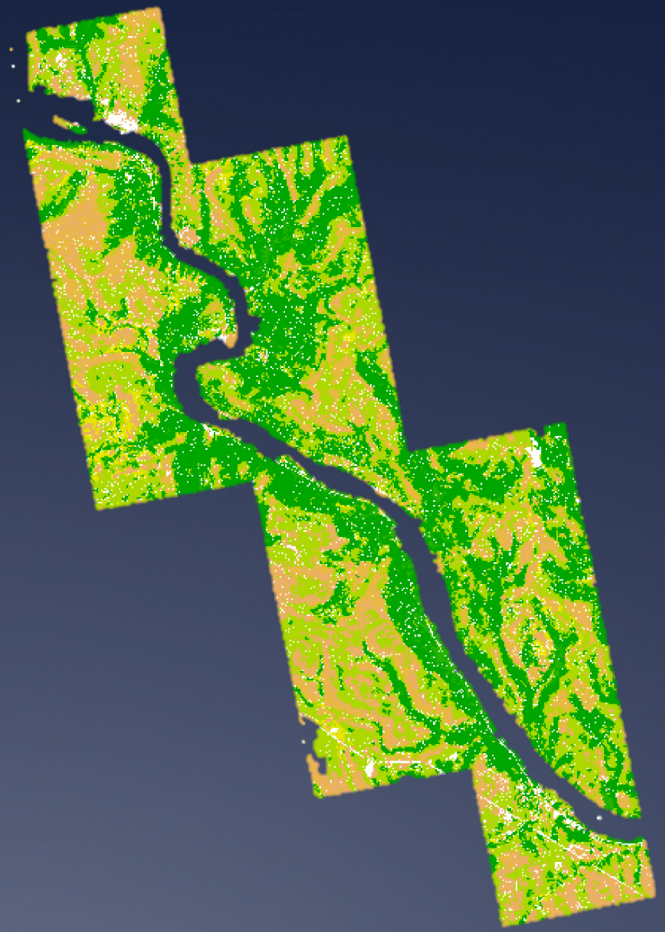
PCA of forest structure

1. First 3 PCs plotted as Red / Green / Blue
2. ~20% of variance explained
3. Can be submitted to clustering algorithms to produce discrete forest classification



Forest Structure Classes

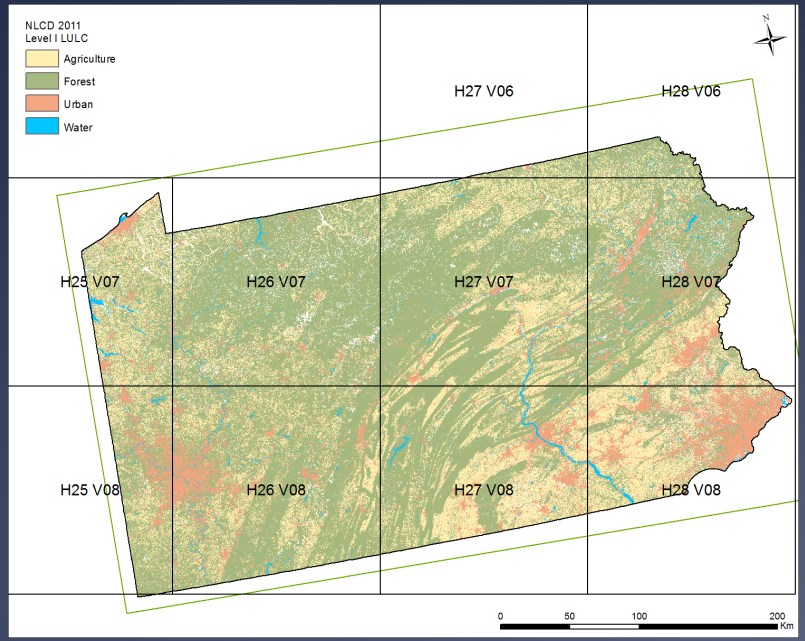


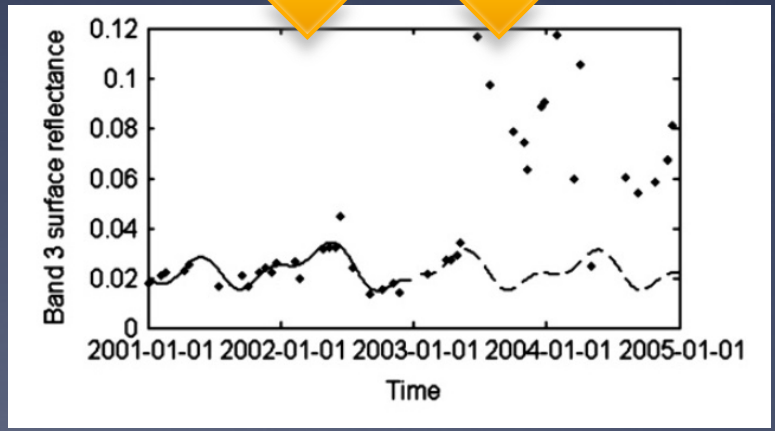


Dickinson et al. *Can. J. For. Res.* 44: 301–312 (2014)

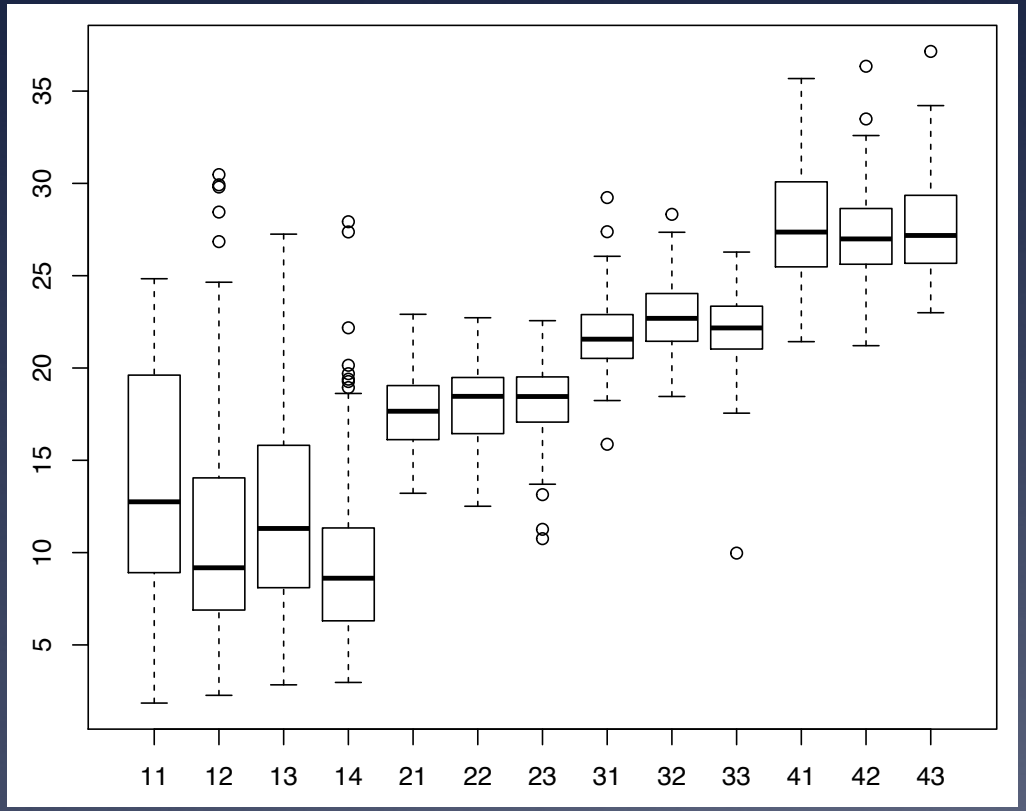
Updating LiDAR forest structure using Landsat time series of forest disturbance

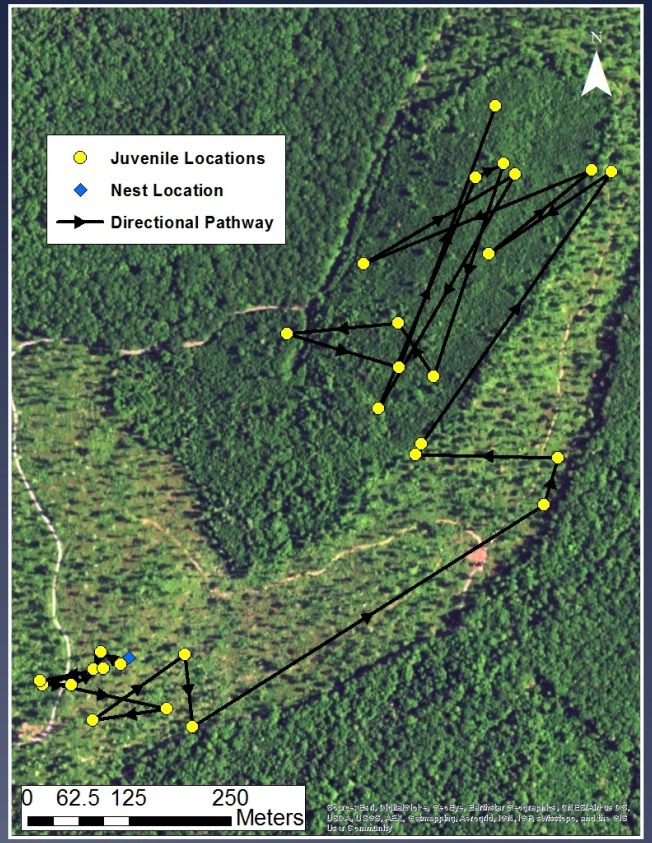
Continuous Change Detection and Classification (CCDC; Zhu et al. (2012))





Example LiDAR metric across classes

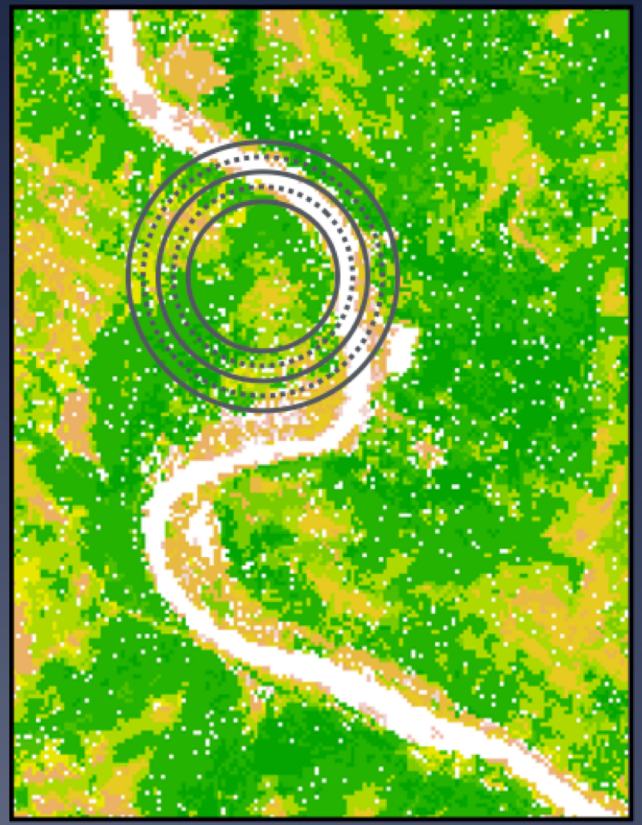




Landscape structure

Focus on quantifying composition & configuration of forest patch types at different distances from patches

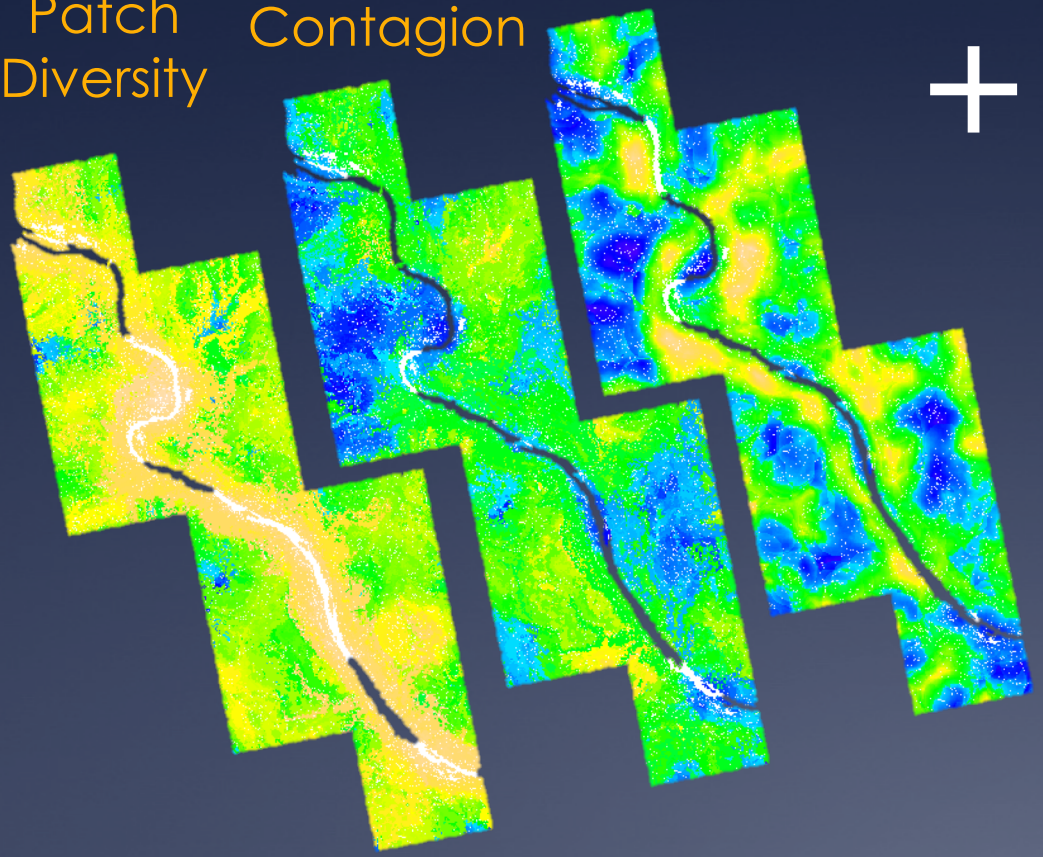
1. Richness – The number of patch classes
2. Shannon's Diversity – accounts for proportional abundance of each class
3. Contagion – accounts for proportional abundance and class adjacency type
4. Shape – ratio of patch perimeter divided by patch area
5. Proximity – sum of patch area and squared distance between patches of the same class
6. Edge density – the total length of edge divided by the focal area



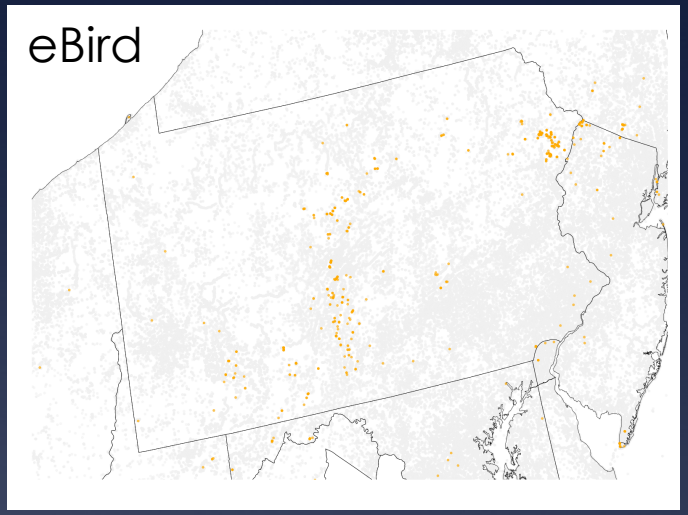
Patch Diversity

Patch Contagion

Cell Contagion



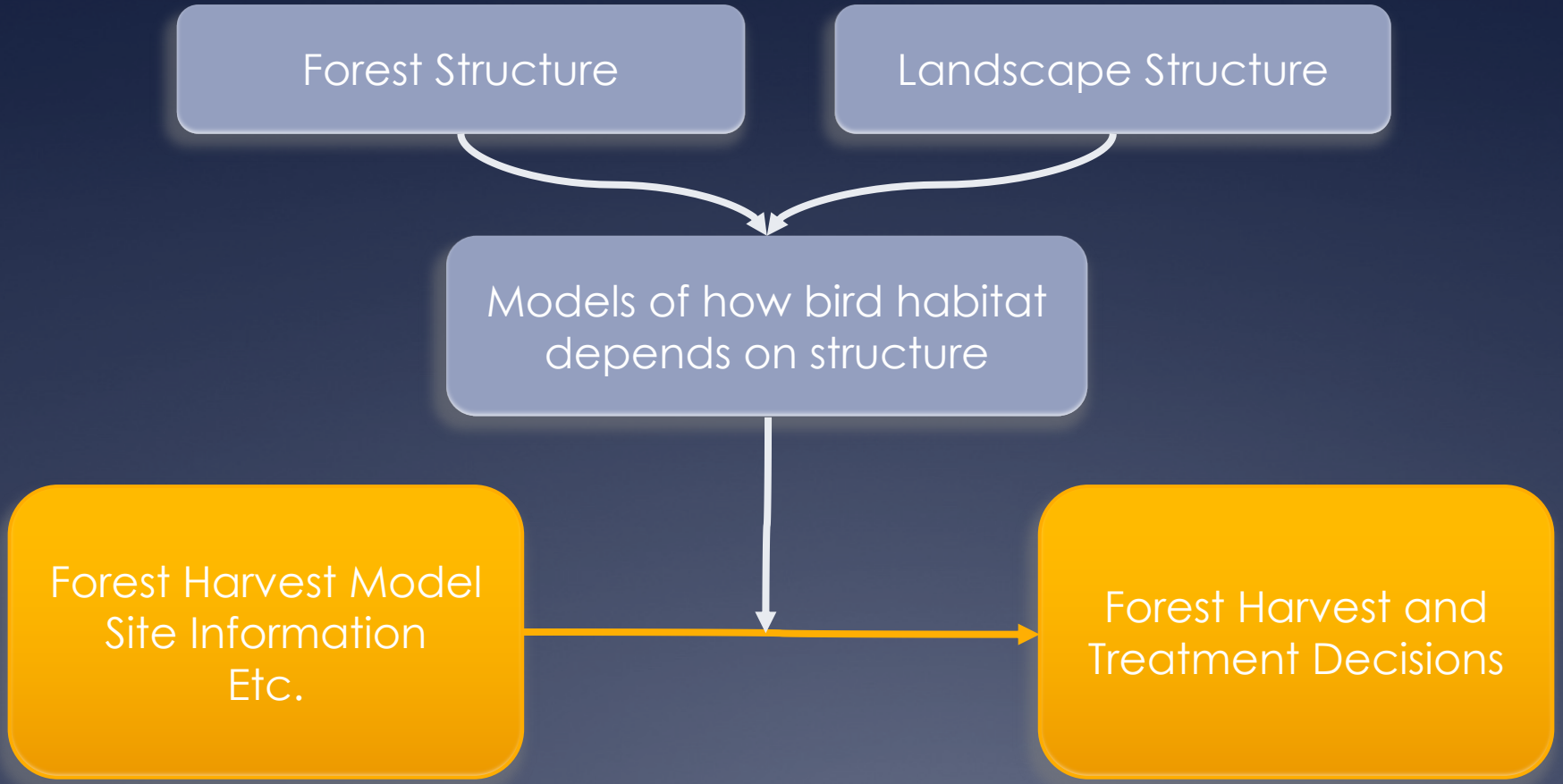
+



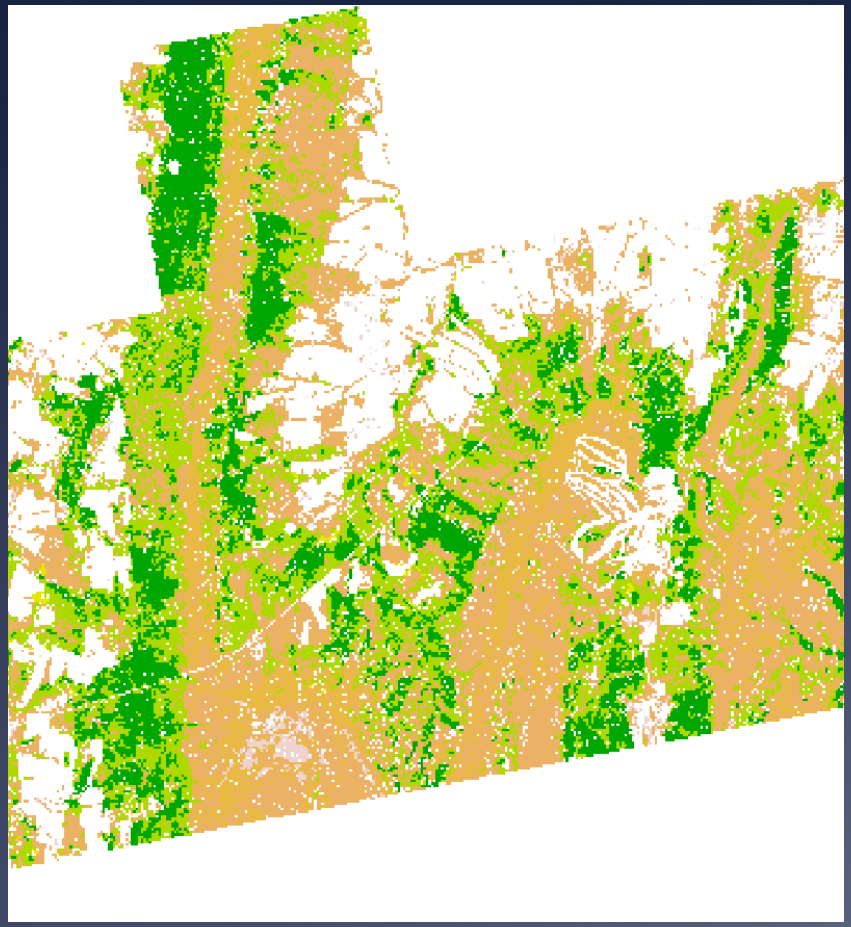
=

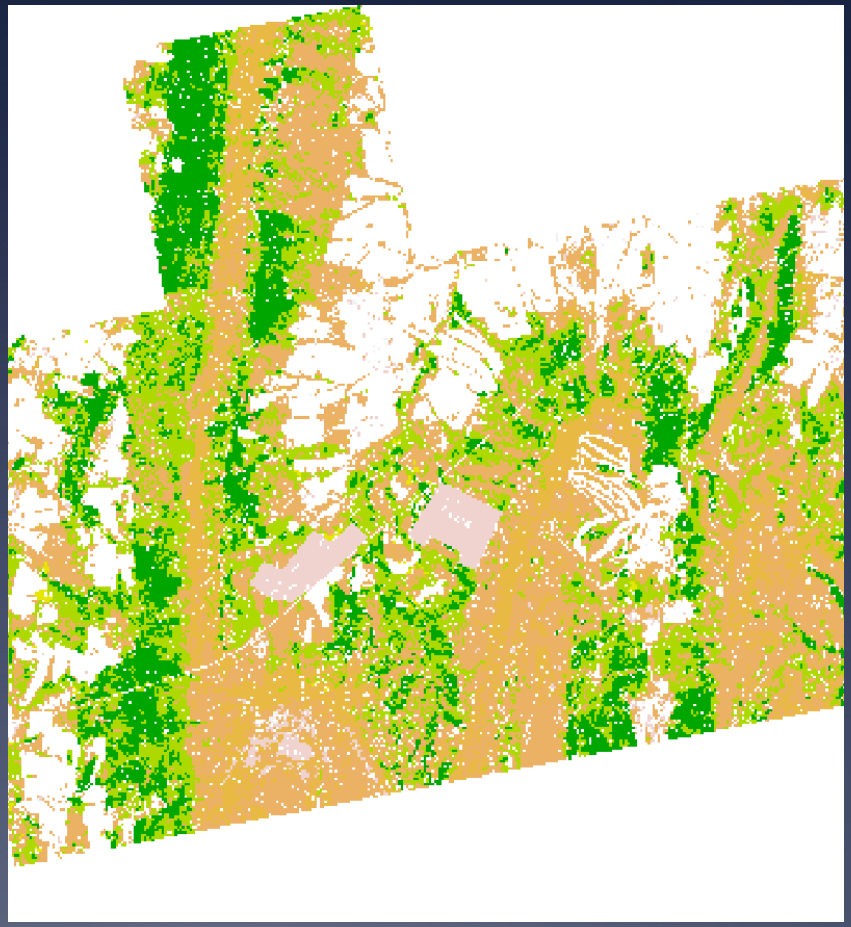
Occupancy models for a suite of bird species of management interest

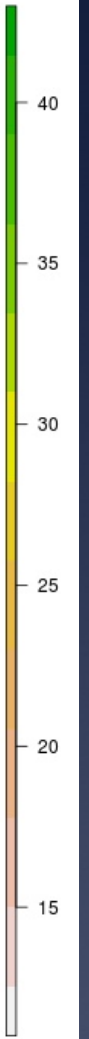
Project Conceptual Diagram



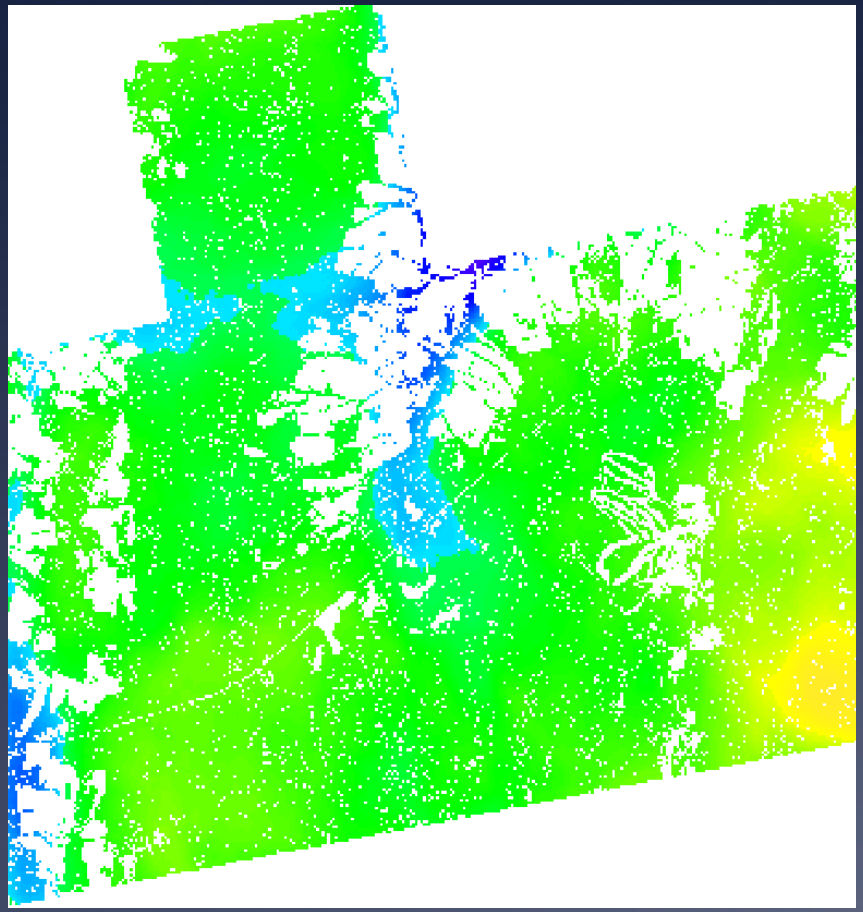
Forest Structure Before and After Harvest

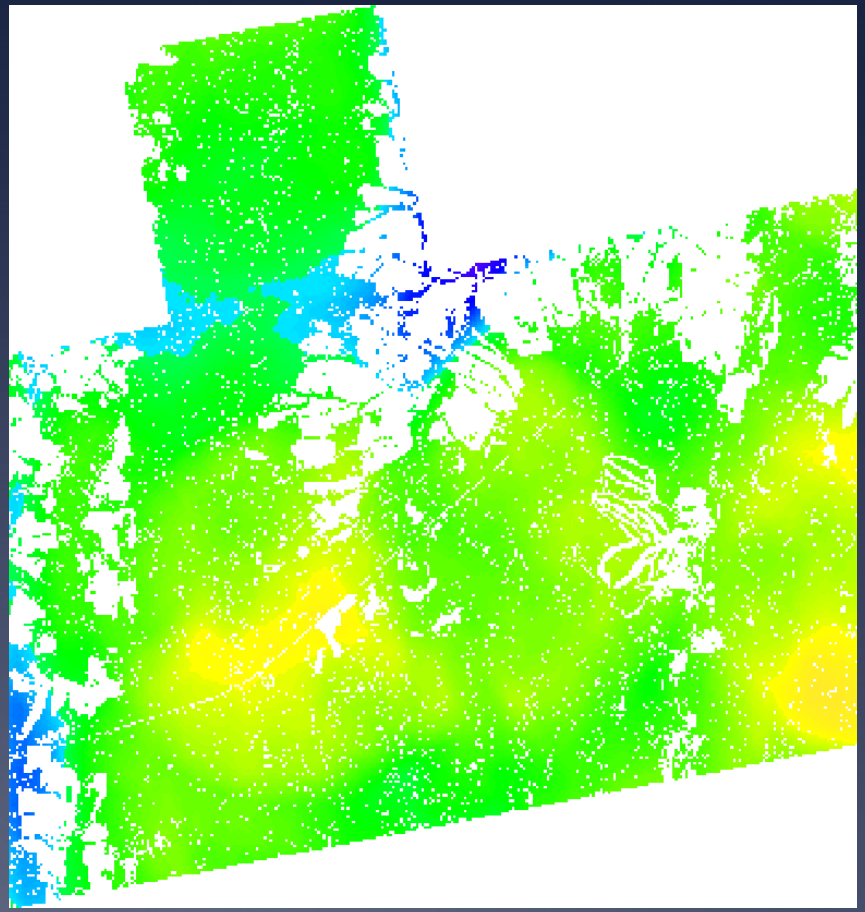






Landscape structure before and after harvest





Things that could go wrong

- Remote sensing-based forest structure won't capture the finer aspects of forest structure important for habitat.
- Landscape structure metrics won't be an important predictor of bird occurrence.
- The model works really well and supports cutting down all the forests to increase bird habitat to the detriment of other species.